Letters to the Editor

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ON THE BINDING ENERGIES OF THE MOST STRONGLY BOUND NUCLEI OF DIFFERENT MASS NUMBERS

A. K. DUTTA, B. PAL, P. GANGULY AND D. BANERJEE

UNIVERSITY COLLEGE OF SCIENCE, 92, ACHARYYA PRAFULLA CHANDRA ROAD, CALCUTTA-9

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In a previous communication (Dutta, 1963), a relation in the form $E = -9.893A + 9.181 \times 10^{-3}.A^2 + 37.0$ Mev., had been put forward, to express the mean course of the nuclear binding energy in relation to mass number. To make the fluctuations symmetrical, the foregoing relationship has been modified for even and odd mass numbers, to the form,

$$E = -9.828A + 8.877 \times 10^{-3} \cdot A^2 + 32{\cdot}6 \pm 0.4 \text{ mev} \quad \ldots \quad (1)$$

according as A is odd or even.

The neutron numbers of the most strongly bound even and odd mass nuclei of different mass numbers have been found to be related to the mass numbers by a nearly linear relationship. A smooth curve through them is expressible as,

$$N_0 = -7.0 + 0.637A + 8.432 \exp - .0267A, \quad \ldots \quad (2)$$

indicating a definite relation for the neutron proton ratio. It gives us the optimum neutron number, N_0, necessary for the most strongly bound condition, for any particular even or odd mass number, and is not necessarily, an integral number. It will enable one to obtain the optimum charge $Z_0 = (A - N_0)$ and the excess neutron $I_0 = (2N_0 - A)$, for any mass number.

The binding energies of the most strongly bound nuclei associated with N_0 values for different mass numbers, deviate from the above relation (1), by a composition of two periodic curves. The independent variables may be considered to be the optimum Z_0 and the I_0 values. The combination of the periodic curves, approximately, measures the deviation of the experimental binding energies of the most strongly bound nuclei (König and others, 1962) of different mass numbers, also. One may express Z_0 and I_0 in terms of A, by relation (2) and, thus, the two periodic curves also, in terms of A.

The two periodic curves are determined by the combination,

$$a_z \sin \pi f(Z) + a_I \sin \pi f(I) \qquad \ldots \quad (3)$$

or,

$$a_z \sin \pi f(Z) + a_I \sin \pi\{f(Z) - \phi\}.$$

where

$$a_z = 11.3 + (4.15 - .00875A) \sin \pi(.656 + .01875A) \text{ Mev.}$$

$$a_I = 10 - 2.7 \sin \pi(.630 + .009258A) \text{ Mev.}$$

$$f(Z) = 3.14 \sinh .01(A\text{-}160)$$

$$f(I) = [f(Z) - \phi]$$

$$\phi = .96 + .22[\exp -1.7\times10^{-3}(A-148)^2 + \exp -1.55\times10^{-2}(A-217)^2]$$

The two phase relations in terms of A, give us the courses of the periodic curves, against mass number scale, obtained in nuclear growth. The amplitudes and the phases of the two periodic curves are mutually adjustable to a small extent, giving a scope for a closer agreement with experimental results. The phase difference is of the order of π. The values of A at the minima and the maxima of the periodic curves, as also the approximate I_0 and Z_0 values, are tabulated in Table I, where they have been arranged in rows.

TABLE I

	max	min	max	min	max	min	max	min	max	min	max
$A(I_0)$	14	28	44	64	85	115	148	176	208	233	256
(I_0)	5	3.4	4.4	8.4	13	18	26	34	43	50	56
	min	max	min	max	min	max	min	max	min	max	min
$A(Z_0)$	13	27	44	64	87	114	144	176	206	233	256
(Z_0)	6	13	20	28	38	48	59	71	82	92	100

The binding energies of the most strongly bound nuclei would be given by the combination of relations (1) and (3) drawn in Fig. 1, except for a small deviation on account of the shift of the integral neutron numbers from the optimum neutron number of N_0. They are shown in Table II, for 51 nuclei from carbon to Mendlevium, running through the complete set. The average error is 0.70 mev. A modification of the relations would be necessary to make them correspond to the energy values associated with the optimum neutron numbers, more closely. This would be taken up later.

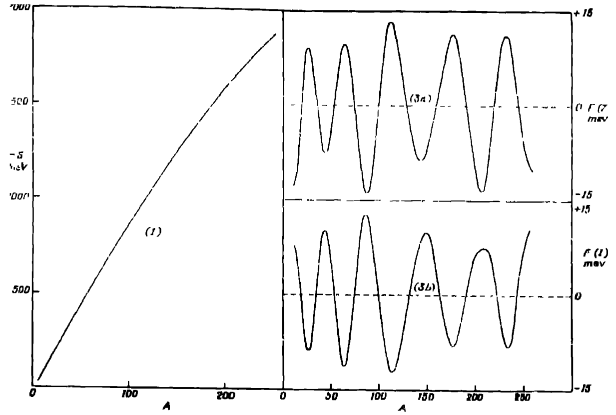

Fig. 2

TABLE II

A	$-E(_{exp})$ mev	$-E(C_{al})$ mev.	A	$-E(_{exp})$ mev.	$-E(C_{al})$ mev.	A	$-E(_{exp})$ mev.	$-E(C_{al})$ mev.
12	92 2	89 1	90	781.2	782 6	175	1412 3	1412 3
15	115 5	116 2	95	821 7	822 9	180	1446 0	1415 8
16	127 6	126 1	100	863 0	863.3	185	1478 6	1478 2
20	160 6	161 7	105	900 5	901 1	190	1512 6	1513 3
25	205 6	206 8	110	940 8	940 6	195	1545 6	1547 4
30	255 6	254 3	115	979 2	979 0	200	1581 1	1582 9
35	298 8	299 0	120	1020 6	1019 5	205	1615 0	1614 9
40	343 8	344 2	125	1057.3	1058 6	210	1645.6	1645 3
45	388 4	388 7	130	1096 9	1098 4	215	1670 1	1670 2
50	437 8	436 4	135	1134 3	1135.0	220	1697 8	1696 8
55	482 1	482 6	140	1172 8	1171.4	225	1725.3	1725 6
60	526 8	527 8	145	1205 2	1204 9	230	1755 2	1755 7
65	569 2	569 8	150	1239 5	1239 5	235	1783.8	1783 7
70	611 1	611 8	155	1273 6	1273 2	240	1813 3	1813 1
75	652.6	652 6	160	1309 8	1309 4	245	1841 5	1840 9
80	696 8	696 3	165	1344 3	1344 2	250	1869 8	1869 2
85	739 5	739 0	170	1379.0	1379 7	255	1894 8	1895 3

The deviations of the binding energies of weakly bound nuclei from those of the most strongly bound nuclei would be discussed in the next communication

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